A flavour-independent search for a hadronically decaying neutral Higgs bosons at LEP with the L3 detector

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International Journal of Modern Physics A,

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General two Higgs doublet models allow for five scalar bosons , three of which being neutral . No signal is found in the data collected by the L3 detector in e^+e^- collisions at $189-202$ GeV center-of-mass energies . Limits are set on the couplings of the h and A Higgs bosons to the Z boson .

1. Motivations

In general two Higgs doublet models of type II ,[1] five scalar Higgs bosons appear after symmetry breaking . We present hereafter a search for the production of the h and A Higgs bosons in the process $e^+e^- \to hZ$ and $e^+e^- \to hA$. We did not use any b-tagging in order to perform a flavour-independent search .

The dominant production mechanisms are the following :

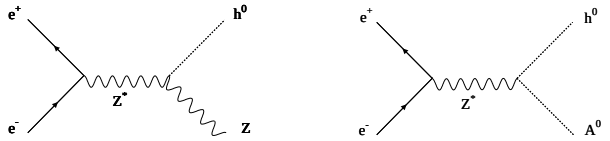

Fig. 1. hZ and hA processes

The cross sections can be parametrized as a function of the Standard Model (SM) cross sections as [1] :

$$\sigma_{hZ} = \rho.\sigma_{hZ}^{SM} \tag{1}$$

$$\sigma_{hA} = \eta\lambda.\sigma_{\nu\nu}^{SM} \tag{2}$$

where σ_{hZ}^{SM} and $\sigma_{\nu\nu}^{SM}$ are the cross sections for $e^+e^- \to hZ$ and $e^+e^- \to \nu\nu$ in the SM , and ρ and η are the couplings , to the Z normalized to the SM ones

$$\rho = \frac{g_{hZZ}^2}{(g_{hZZ}^{SM})^2} \tag{3}$$

$$\eta = \frac{g_{hAZ}^2}{(g_{Z\nu\nu}^{SM})^2} \tag{4}$$

and λ is a phase space factor .

2. Data sample

We used data taken by the L3 detector . The integrated luminosity analysed represents 410 pb^{-1} , at center-of-mass energies ranging from 189 to 202 GeV .

3. Analysis $e^+e^- \to hZ$

Three channels were used to perform this analysis : $hZ \to q\bar{q}q\bar{q}$, $hZ \to q\bar{q}\nu\bar{\nu}$ and $hZ \to q\bar{q}l^+l^-$. For the four jet analysis , the main background is $e^+e^- \to W^+W^-$, and $e^+e^- \to ZZ$ for missing energy and leptonic channels . We use the constraint that the invariant mass of two jets , two leptons or the missing mass , should be consistent with the mass of the Z boson . The analysis procedure is described in Reference [2] . Since no evidence for a signal is observed , a 95% Confidence Level (CL) exclusion limit on ρ is derived as function of the mass of the Higgs, assuming the branching ratio of the Higgs into hadrons to be as in SM (Figure 2).

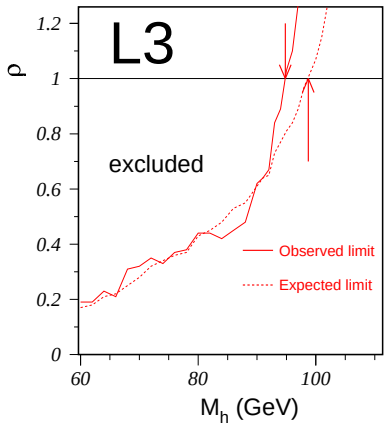

Fig. 2. Limit on the parameter ρ as a function of M_h.

Assuming SM coupling ($\rho = 1$), the lower mass limit obtained for h in this process is : $M_h \geq 94.8$ GeV . This value is lower than the one in the SM Higgs analysis ($M_h \geq 106.0$ GeV) , as we did not use any b-tagging .

4. Analysis $e^+e^- \to hA$

Two Higgs decay channels are studied : $h, A \to q\bar{q}$ or $\tau^+\tau^-$. The main SM background is $e^+e^- \to W^+W^-$. As in the previous hZ analysis , a kinematic fit is applied in order to require energy and momentum conservations for $q\bar{q}q\bar{q}$ final states. Also there , no excess is observed and in Figure 3 is shown an exclusion plot in the plane (M_h, M_A) , for different values of η' , where $\eta' = \eta * BR(hA \to q\bar{q}q\bar{q})$. The most constrained region is the darkest one , corresponding to $\eta' = 0.5$.

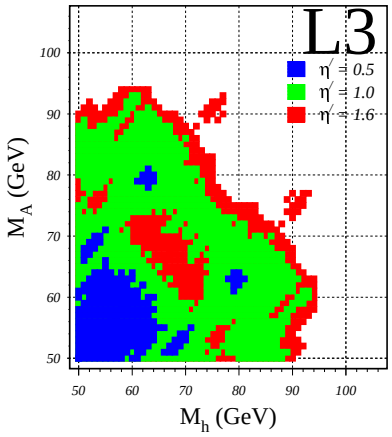

Fig. 3. The 95% CL excluded (M_h, M_A) region for the production of $hA \to q\bar{q}q\bar{q}$, for different assumptions of η' .

Assuming $M_h = M_A$, the lower mass limit obtained with $\eta' = 1$ for the process $hA \to q\bar{q}q\bar{q}$ is : $M_{h,A} \geq 64$ GeV . Concerning the process $hA \to q\bar{q}\tau^+\tau^-$, the procedure is the same as described in Reference [3] . Assuming $M_h = M_A$ and $\eta' = 1$, we obtained : $M_{h,A} \geq 85$ GeV .

5. Conclusion

No excess of candidates , with respect to the SM predictions , were found in those flavour-independent hZ and hA searches ; hence the following 95% CL limits are derived .

For the process $hZ \to q\bar{q}f\bar{f}$ and $\rho = 1$:
$M_h \geq 94.8$ GeV .
For the process $hA \to q\bar{q}q\bar{q}$ and $\eta' = 1$ (assuming $M_h = M_A$) :
$M_{h,A} \geq 64$ GeV .
For the process $hA \to q\bar{q}\tau^+\tau^-$ and $\eta' = 1$ (assuming $M_h = M_A$) :
$M_{h,A} \geq 85$ GeV .

References

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2. L3 Collaboration, M.Acciarri *et al.*, Phys. Lett. B 461 (1999) 376.
3. L3 Collaboration, M.Acciarri *et al.*, Phys. Lett. B 471 (1999) 321.